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# Web Based Application for Remote Controlled Lunar Exploration Robotics Incorporating AI



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## 1. Project Summary

The project was to develop a web-based application to simulate the control of lunar exploration robots, using the Lego Mindstorms EV3 robotic kits. The development incorporated AI to simulate the communications delay, and for pathfinding and anti-collision measures. This could be used to train operators that control robots remotely. This project was not a success, and is explained during the development and analysis sections.



Figure 1: Lego Mindstorms EV3 logo [1]



Figure 2: Lunar exploration robot [2]

## 2. Project Aims & Objectives

The aim of this project was to create a web-based simulator to train operators to control a Lego Mindstorms robot using a wireless communication network, whilst applying a realistic delay to the communications. To achieve this, the project had the following objectives:

- A literature review to determine any existing Lego or rover simulators, and compatible programming languages and IDE's to program the Lego Mindstorms EV3 robot.
- To design and create at least one Lego robot for testing purposes.
- To create an application based upon the research conducted, incorporating AI aspects to simulate communications delay and hazard

awareness, based upon data received from sensors and human input.

- To test the simulator on the Lego robot, and analyse and evaluate the simulator.

## 3. Methodology

This project followed an agile approach, known as feature driven development (FDD) methodology, due to the ease of design, development and testing. It is a timeboxed approach, which allowed for the addition of features within each timebox, prioritising the completion of the aims, objectives and the success criteria. It was developed using the Lego Mindstorms kit, LeJOS and Java.

## 4. Design & Development - The Build Process

Over the six timeboxes, both the rover and application was developed into the final result. Web services was used between the control and operator devices, with the connection between the operator and rover using sockets over a Bluetooth connection. Both were tested when new changes, such as the addition of AI, or when classes were added to allow for the creation of the system architecture:



Figure 3: System Architecture Diagram

There are two main issues with the application:

1. The application does not connect to the rover, despite several attempts to rectify this. It is narrowed down to a network configuration.
2. The Java Plugin is not supported by modern browsers.



Figure 4: Final Web Application Design

## 5. Analysis

A questionnaire was used to gather information about the application, with the aim to prove or disprove the hypothesis. It is split into 3 sections, and was carried out by ten people after piloting:

1. System usability scale (SUS) - Score of 32.4/50 (64.8%).
2. Hardware & software issues - Connectivity and the web application.
3. Operational Data - This data could not be collected due to the issues with connectivity, but would be analysed using a two sampled T-test.

## 6. Recommendations & Expansion Plans

- Dual connectivity - Wi-Fi and Bluetooth connections
- Smartphone and tablet applications
- Solve the connection issues
- Additional structural support for the rover frame
- Web browser compatibility
- Additional colour and visual representation of sensor feedback - CSS

## 7. References

- [1] NeXTSTORM, 'LEGO MINDSTORMS EV3 - Announcement Day', YouTube, 2013. [Online]. Available: <https://www.youtube.com/watch?v=urpXeGRD8TA>. [Accessed: 03-Oct-2017].
- [2] B. Dunbar and NASA, 'NASA - Lunar Rover Field Tests', NASA, 2008. [Online]. Available: [https://www.nasa.gov/centers/ames/multimedia/images/2008/amos\\_lake.html](https://www.nasa.gov/centers/ames/multimedia/images/2008/amos_lake.html). [Accessed: 03-Oct-2017].